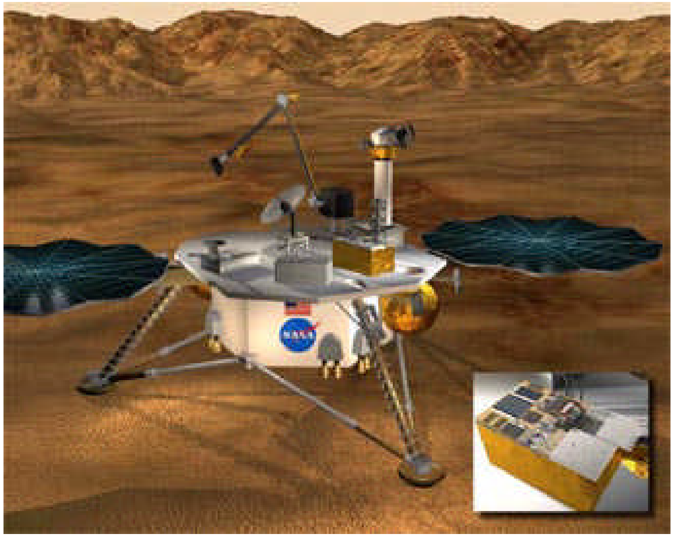
DART: Instrument Package Developed for Investigating Atmospheric Dust on Mars



Artist's conception of Mars-2001 Surveyor Lander, with an inset showing the DART experiment package.

Mars' dust-filled atmosphere could be a significant problem for photovoltaic array operation during long missions on the surface of Mars. Measurements made by Pathfinder showed a 0.3-percent loss of solar array performance per day due to dust obscuration. Thus, dust deposition is the limiting factor in the lifetime of solar arrays for Martian power systems, and developing design tools to mitigate this deposition is important for long missions.

Despite the fact that dust deposition will severely degrade solar arrays, few details are known about the physical properties of Mars dust. The Dust Accumulation and Removal Test (DART) instrument was designed to gather this needed information: to quantify dust deposition, to measure the properties of the settled dust and its effect on array performance, and to test several ways to mitigate the effect of settled dust on a solar array. Although DART's purpose is to gather information critical to the design of future power systems on the surface of Mars, it will also provide significant scientific data on the properties of settled atmospheric dust through its dust characterization instrumentation. Two instruments will characterize dust: the dust microscope and the materials adherence experiment (MAE) commandable dust cover. In addition, two dust-mitigation tests will be conducted: tilted cell tests and an electrostatic dust-repulsion test.

DART's fixed-focus microscope is intended to furnish information about the size distribution of the settled dust. As atmospheric dust settles on DART's transparent glass settling plate, it will be imaged from below through a 340 objective that focuses onto a

512- by 512-pixel CMOS focal plane array. The microscope's resolution is about 0.5 mm, and its total mass is 200 g. Since settled dust may be different in character from the dust that remains suspended in the atmosphere, this information is of considerable interest in the design of dust-mitigation strategies. For larger particles, the DART microscope will also yield shape information.

The MAE dust cover, which is based on the experiment flown on Path-finder, consists of a transparent plate onto which dust settles. This plate is located above three small solar cells used in short-circuit current mode to measure solar intensity in three wavelength bands. A mechanism allows the cover to be rotated away from the cells. Comparison of the cell output with the dust-covered plate in position and removed measures the dust coverage independently of other changes in the cell performance or the atmosphere. By taking a spectrum of the sunlight through the MAE settling plate, we can also obtain a transmission spectrum of the settled dust.

Measurements of the camera window on the Viking lander showed no dust adhering to the vertical surface. Observations of the thermal shell of the Viking landers seemed to show that dust also did not build up on tilted surfaces. Unfortunately, no quantitative measurement of the accumulation could be made. A high priority is, therefore, to see whether tilted solar cells avoid dust accumulation, and to find what angle is required to avoid dust coverage. The tilted cell measurement consists of solar cells tilted at 30°, 45°, and 60°; a horizontal control; and another solar cell tilted at 30° with a low friction (diamondlike carbon) coating.

The Martian atmospheric dust is expected to be charged. The electrostatic experiment will use a high-voltage solar cell to provide a potential of about 80 V to a transparent conductor on the front surface of the solar cell cover-glass. It will test three configurationsa positive potential applied to the cell cover, a negative potential applied to the cell, and a transverse field applied across the cellto determine whether electrostatic fields can be used to mitigate the deposition of dust on solar arrays. These configurations will be compared with the control cell with no applied potential.

DART's sensors will provide both scientific information and important engineering data on the operation of solar power systems on Mars. DART will measure the dust accumulation rate and the transmitted spectrum of the dust, and it will image individual settled particles to determine the size distribution and the particle shape, as well as gather information on electrostatic properties. DART was developed to fly as part of the MIP experiment on the (now postponed) Mars-2001 Surveyor Lander. The flight hardware was designed, built, and qualified for flight at the NASA Glenn Research Center, and it is ready to go to Mars.

DART Experiment flight hardware prepares for testing. The experiment team poses with the test hardware. Clockwise from upper left: John Lekki--Glenn, software engineer; Phillip Jenkins--Ohio Aerospace Institute, lead engineer for DART; Geoffrey A. Landis--Glenn, principal investigator for DART; and David Scheiman--Ohio Aerospace Institute, principal investigator for MATE.

Find out more about DART:
http://powerweb.grc.nasa.gov/pvsee/publications/mars/Mars99.html

References

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